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(54) Crystal resonator

(57) A package for a quartz crystal resonator (133) comprises two housing members (31,32) made of quartz of the same cut and orientation as the resonator. This minimises the effect of the package on the resonator characteristics. A method of making the package is also described using selective etching with a fluorine coating plasma.

Fig.3.

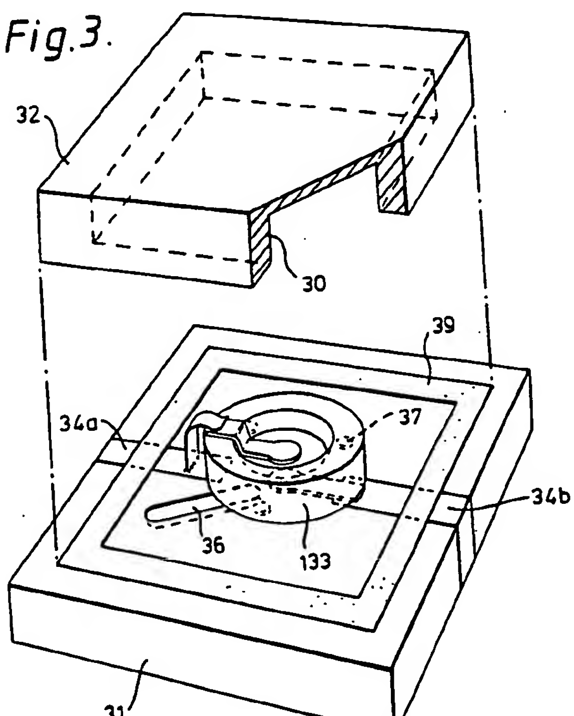

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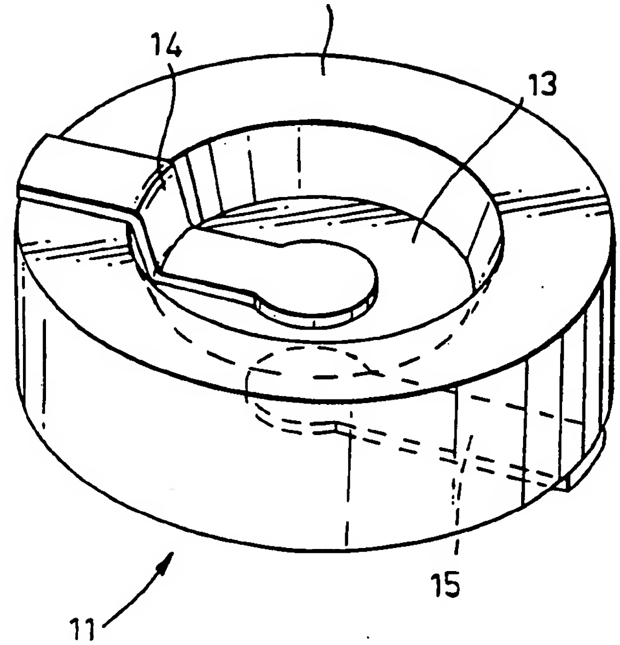
Fig. 1.



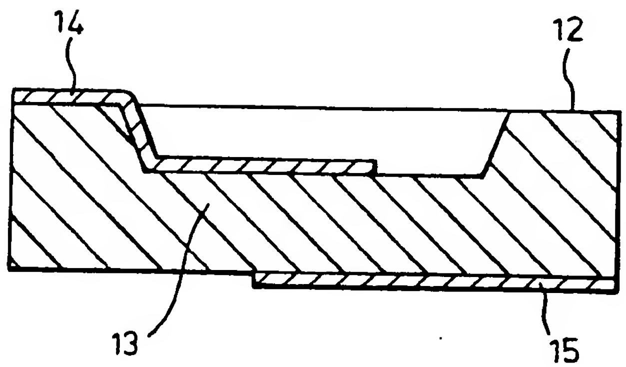


Fig. 2.

Fig.3.

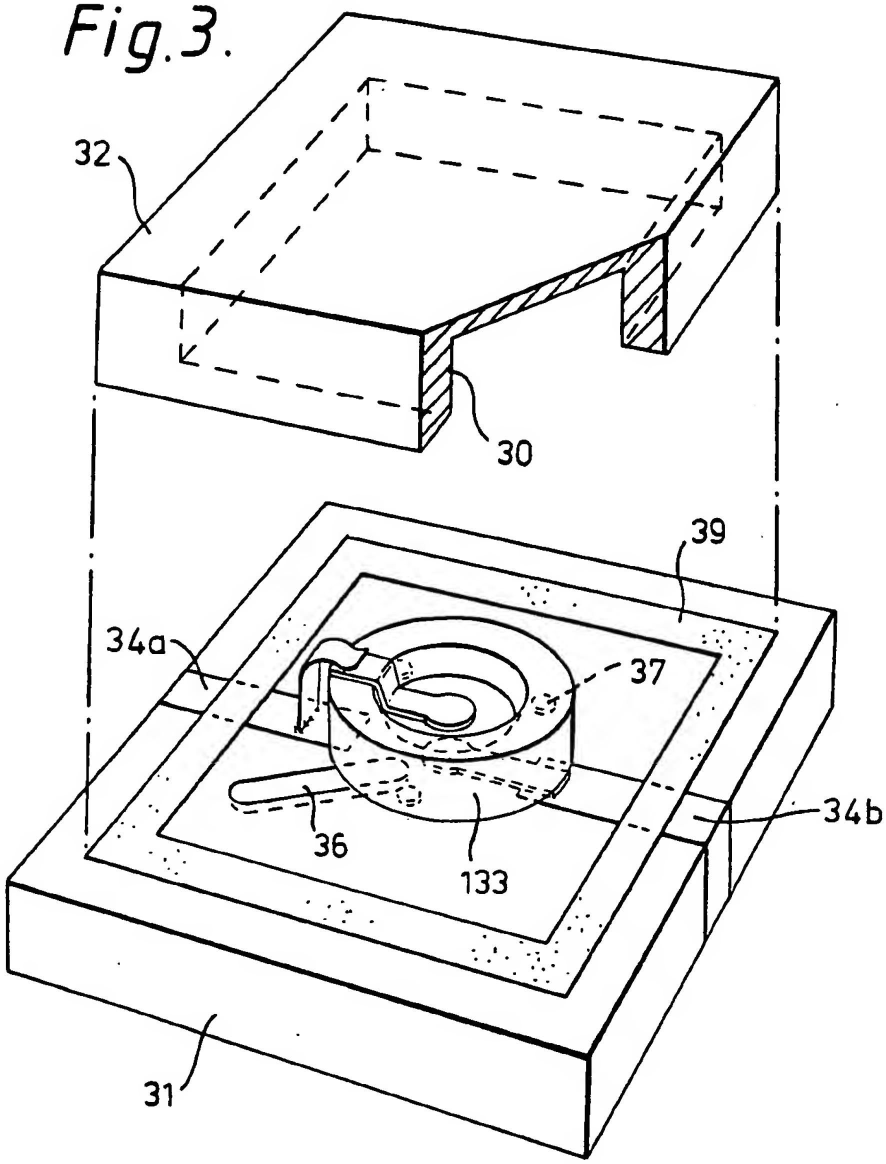
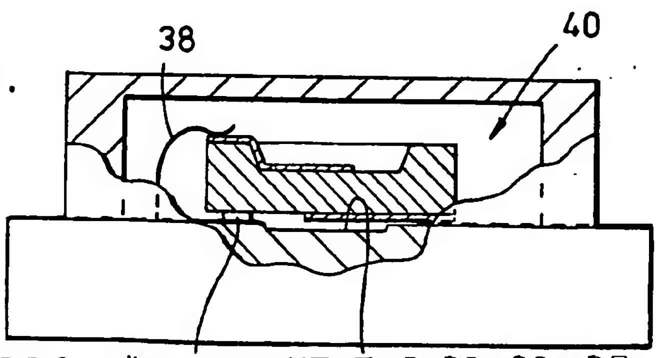


Fig.4.



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CRYSTAL RESONATOR

This invention relates to crystal resonators and in particular to packaging of such resonators.

Piezoelectric resonators, e.g. quartz crystals, are used as frequency standards in a wide range of applications. However, their use at high frequencies has been restricted by a number of factors. One factor that becomes significant at high frequencies in the effect of the device package on the resonator characteristics. At high frequencies the dimensions of the active part of the resonator is very small and is thus very sensitive to perturbations by strains applied from the package. This strain generally arises from thermal mismatch between the package and the resonator. This effect is not of course significant at the lower frequencies of conventional devices. Various techniques have been proposed for reducing mechanical coupling between the package and the resonator, but these have proved unsuitable for small and delicate high frequency devices.

The object of the present invention is to minimise or to overcome this disadvantage.

According to one aspect of the invention there is provided a crystal resonator assembly, including a crystal resonator, and first and second housing members mated together to define a cavity in which the resonator is located, wherein the housing members are formed each from the same crystal material and have the same crystal orientation as the resonator.

According to another aspect of the invention there is provided a method of making a two-part package assembly for a crystal resonator, the method including cutting from a body of the crystal material first and second members of the same crystal orientation as the resonator, selectively plasma etching each member with a fluorine coating plasma to form a recess, the member and recesses being such that when two blocks are placed together their recesses define a cavity adapted to accommodate the resonator, applying first and second metallised tracks to one said member, placing the resonator in the recess of the one said member and coupling the resonator electrically to said metallised tracks, placing the other member in abutment with the one said member so as to locate the resonator in the cavity defined by the recess, and sealing the two members together to form a package.

In the past of the use of crystal material to form the device package had not been considered feasible. For conventional low frequency devices the effect of the package is not a significant problem. For high frequency devices the problem of the effect of the packaging has only recently been appreciated following attempts to use these devices in close tolerance applications, such as multiple filters, where a high degree of long term frequency stability is required. Prior to the present invention it was thought that manufacturing difficulties involved in machining a highly intractable material such as quartz precluded the use of one material for both the resonator and the package. We have now found that a package can be fabricated from bulk material by a plasma etching process. Surprisingly this has been found to provide the necessary definition and control to allow package to be formed reproducibly and at relatively low cost.

An embodiment of the invention will now be described with reference to the accompanying drawings in which:-

Fig. 1 is a general view of a high frequency crystal resonator;

Fig. 2 is a sectional view of the resonator of Fig. 1;

Fig. 3 shows a package construction from the resonator of Figs. 1 and 2,

and Fig. 4 is a cross-section of the package of Fig. 3.

Referring to Figs. 1 and 2, the resonator comprises a disc 11, e.g. of quartz, having an outer supporting rim 12 and an inner recessed portion 13 of reduced thickness. This reduced thickness portion 13 provides the active element of the resonator. Electrical contact to the reduced thickness portion 13 is made via upper (14) and lower (15) metal electrodes deposited on the upper and lower surfaces respectively of the resonator. Typically the reduced thickness portion 13 is from 2 to 4mm in diameter and 10 to 50 microns in thickness. The device frequency is determined by the thickness of the portion 13. For example, a thickness of 13 microns corresponds to a resonant frequency of 127 MHz.

The resonator of Figs. 1 and 2 may be fabricated using the process described in our co-pending UK patent application No. 8707930 ~~(R.A.H. Heinecke — R.J. Williamson 45-22)~~ of even date.

A package construction for the device of Figs. 1 and 2 is shown in Figs. 3 and 4. The package comprises two housing members 31,32 each found from the same crystal material as the resonator 33 and each of the same crystal cut and orientation as the resonator. The lower housing member 31 is larger than the upper housing member 32 and is provided with metallised tracks 34a,34b whereby electrical connection to a packaged device is effected. A circular recess 35 is formed on the inner surface of the housing member 31 in communication with a groove 36. The upper housing member 32 has a relatively large recess 37 in its inner surface, this recess being of sufficient size to accommodate the resonator device 33. Typically the housing members 31 and 32 are fabricated by plasma chemical machining from bulk quartz. A body of bulk quartz of the

same material and crystal orientation is sawn into blanks. The blanks are polished and are then selectively plasma etched using an out of contact stencil mask. Etching is effected by exposing the masked blanks to a radio frequency plasma containing a fluorinated hydrocarbon. The blanks are mounted e.g. on a graphite support, and a stencil mask, e.g. of silicon, is placed adjacent the blanks. Typically the mask is spaced from the blanks by a distance of about 0.2mm to ensure that the boundaries of the etched regions are sounded. This reduces the risk of breaks in subsequent metallisation. The masked blanks are exposed to a radio frequency plasma containing either a fluorinated hydrocarbon, e.g. CF_4, C_2F_6 or C_3F_8, sulphur hexafluoride or mixtures thereof. The pressure is typically 0.1 to 0.8 torr. Thus, the process takes place in the medium pressure reactive ion etching mode. Under these conditions, and with an input power in the range 1 to 10 kwatts we have achieved etch ratio in excess of 0.3 microns/minute. After etching is complete the lower portion of each housing assembly is metallised, e.g. by vacuum evaporation of aluminium, silver or gold, to form the tracks that provide contact to a mounted device. The groove in the lower housing member is etched in a separate process, preferably before the process described above.

The package construction is assembled in the following way. The resonator 33 is placed recess side down on the lower housing member 31 in register with the recess 35 and is secured to the housing member 31 via three pads 37 of a silver loaded low melting point glass. One of the pads 37 provides electrical connection between the metal track 33 of the housing member and the front electrode 14 (Fig. 1) of the resonator. A flying lead 38 coupled the metal track 34 to the back electrode 15 of the resonator. The upper housing member 32 is then placed in contact with the lower housing member 31 and is secured thereto e.g. by a film 39 of low melting point glass. Alternatively, electrostatic bonding of the housing members may be employed. The groove 36 in the lower housing member 33 is

so disposed that it provides communication between the recess 35 in the lower housing member and the cavity 40 defined by the material housing members. This cavity 40 may be evacuated or it may be filled with an inert gas such as helium or nitrogen. Helium filling is preferred as the high thermal conductivity of the gas inhibits temperature gradients within the package. The finished assembly may be mounted on a carrier (not shown) whereby electrical connection is provided to the metal tracks 33,34 on the lower housing member.

In an alternative construction, smaller housing members may be employed and mounted directly on the rim of the resonator.

CLAIMS:-

1. A crystal resonator assembly, including a crystal resonator, and first and second housing members mated together to define a cavity in which the resonator is located, wherein the housing members are formed each from the same crystal material and have the same crystal orientation as the resonator.

2. A crystal resonator assembly, including a crystal resonator having a pair of electrodes disposed thereon, a first housing member on which the resonator is mounted and having first and second metallised regions coupled each to a resonator electrode, and a second housing member sealed to said first member so as to define a cavity therebetween in which cavity the resonator is disposed, wherein the first and second housing members are formed each from the same crystal material and have the same crystal orientation as the resonator.

3. A method as claimed in claim 1 or 2, wherein said cavity is filled with helium.

4. A method as claimed in claim 1, 2 or 3, wherein the resonator is secured to one housing member via a silver loaded glass, said glass providing electrical contact between the resonator and one said metallised region.

5. A crystal resonator assembly substantially as described herein with reference to and as shown in Figs. 3 and 4 of the accompanying drawings.

6. A method of making a two-part package assembly for a crystal resonator, the method including cutting from a body of the crystal material first and second members of the same crystal orientation as the resonator, selectively plasma etching each member with a fluorine coating plasma to form a recess, the member and recesses being such that when two blocks are placed together their recesses define a cavity adapted to accommodate the resonator, applying first and second metallised tracks to one said member, placing the resonator in the recess of the one said member and coupling the resonator electrically to said metallised tracks, placing the other member in abutment with the one

said member so as to locate the resonator in the cavity defined by the recess, and sealing the two members together to form a package.

7. A method as claimed in claim 6, wherein the members are plasma etched in an atmosphere of CF_4, C_2F_4, C_3F_8, SF_6 or mixtures thereof.

8. A method as claimed in claim 6 or 7, wherein said cavity is filled with helium.

9. A method of making a two-part assembly for a crystal resonator, which method is substantially as described herein with reference to and as shown in the accompanying drawings.